

A Bloch Wave Model that Describes the Dispersive Effects in Photonic Crystals

B. Lombardet, L. A. Dunbar, *R. Ferrini and R. Houdré,

Institut de Photonique et d'Electronique Quantique, *Laboratory of Optoelectronics of Molecular Materials, Ecole Polytechnique Fédérale de Lausanne, CH-1015 Lausanne, Switzerland.

Phenomena such as negative refraction, high dispersion and self-collimation have been numerically modelled and experimentally observed in Photonic Crystals (PhCs). However, as yet, little work has been published on the physical interpretation of these effects in PhCs. We will present an original description based on the Fourier transform of electromagnetic Bloch waves that are the standard representation of the optical field propagating in periodic media. Initially, we will consider an electromagnetic Bloch wave propagating in a PhC and demonstrate that it can be decomposed into a series of partial-electromagnetic plane waves. The properties of these constitutive plane waves will be discussed, and their individual contributions to the total energy and group velocity of the global Bloch wave detailed. The validity of the decomposition will be shown for TE and TM waves in both the one- and two-dimensional case.

This original approach brings an intuitive understanding to light propagation in PhCs, in particular it gives a continuous description of the light properties when moving from a homogenous to a strongly modulated medium. Moreover, it also resolves inconsistencies resulting from the artificial band folding for vanishing modulations, as were originally pointed out by *Notomi* [1]. Using the model we will describe the unusual properties of light propagation in PhCs. Finally, we will discuss these compare with similar properties seen in left-handed materials.

[1] M. Notomi, *Physical Review B*, **62**, 10696 (2000).